

REMARKS

In accordance with the foregoing, claim 5 is amended and new claims 40 – 46 are added to the application. No new matter is presented in this Amendment.

Rejection of claim 5 under 35 U.S.C. §112:

At page 5 of the Office Action, claim 5 was rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite. The Examiner questioned how elemental sulfur particles having an average particle size of 20  $\mu\text{m}$  could be disposed in pores having an average pore size of less than and including 15  $\mu\text{m}$ .

Claim 5 is amended to provide that an average particle size of the elemental sulfur is up to 15  $\mu\text{m}$ . Accordingly, since the amended claim 5 does not recite an average particle size greater than an average pore size, the claim is not indefinite. Therefore, the rejection should be withdrawn.

Rejection of claims 1 – 4, 8 – 9, 17, and 38 – 39 under 35 U.S.C. §103 over Chu in view of JP '431

At page 4 of the Office Action, claims 1 - 4, 8 - 9, 17, and 38 - 39 were rejected under 35 U.S.C. §103(a) as allegedly obvious in view of Chu (U.S. Patent No. 5,523,179) and Japanese patent publication no. 47-28431 (hereinafter referred to as "JP '431"). The Examiner alleged that Chu discloses battery cells comprising a sulfur-based positive composite electrode wherein the active sulfur is elemental sulfur or sulfur containing discharge products of elemental sulfur and a negative electrode that comprises lithium metal or lithium-metal alloys. The Examiner further alleged that Chu discloses that the battery cell has a separator and an ion-conducting electrolyte. The Examiner acknowledged that Chu does not disclose a specific pore size and does not disclose the pore size recited in claim 3. The Examiner alleged that the JP '431 publication discloses a sodium-sulfur secondary battery with low voltage drop because of contact resistance wherein the battery comprises a cathode activator of a melted sulfur and that sulfur is an electric insulator so that it is necessary to increase conductivity of the sulfur to react electrochemically in the battery. The Examiner alleged that JP '431 discloses that it is essential to use a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000  $\mu\text{m}$  as a cathode member to increase the conductivity of the cathode. The Examiner took the position that it would have been obvious to make Chu's positive active material including sulfur by having the specific pore size of the JP '431 publication because the

JP '431 publication reveals that in a battery system using sulfur it is essential to use a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000  $\mu\text{m}$  as a cathode member to increase the conductivity of the cathode. The Examiner alleged that such cathodes having the specific pore size are better conductors and can be used in electrochemical applications involving alkali-metal technology. The Examiner further alleged that since the prior art directly teaches a pore diameter of at least 10 – 15  $\mu\text{m}$ , a *prima-facie* case of obviousness still exists. Moreover, the Examiner alleged that JP '431 and the present application share the same field of endeavor as they both address and disclose alkali metal-sulfur based batteries and their related technologies. For the following reasons, this rejection is respectfully traversed and reconsideration is requested.

In the English translation of the entire disclosure of JP '431 that was provided by the Examiner in the Office Action, it can be clearly seen that JP '431 does not relate to the same field of endeavor as the present invention and that it is not reasonably pertinent to the particular problems address in the present invention. In particular, JP '431 is specifically directed to the problem of providing conductivity to a molten sulfur electrode in a high temperature electrochemical cell. Claim 1 is amended herein to clarify that the active sulfur is in the form of solid phase elemental sulfur (S8) and/or a polysulfide solution. Therefore, persons skilled in the art evaluating the teachings of JP '431 would interpret these teachings in the context of the problem of providing conductivity to molten sulfur and would understand that physical and electrical properties of molten sulfur would be significantly different from the physical and electrical properties of a solid phase elemental sulfur (S8) and/or a polysulfide solution. JP '431 contains no teachings relevant to problems addressed in the present claims such as, for example, preventing the active material in the form of solid phase elemental sulfur (S8) and/or a polysulfide solution from diffusing from active sites of the positive electrode. Therefore, JP '431 is non-analogous art that is not reasonably pertinent to the problems addressed in the present invention.

Moreover, although JP '431 describes pore sizes of 10 – 1000  $\mu\text{m}$ , even if this teaching could be applied to the present invention, there is nothing in JP '431 that would guide a person skilled in the art from this extremely broad range to the specific, narrow average pore size range of greater than or equal to substantially 5  $\mu\text{m}$  and less than and including 15  $\mu\text{m}$ . It can be clearly seen in the English translation that the reference teaches away from the lower range of pore sizes. In particular, it is described in the paragraph at the top of the second page of the English translation that a small pore size inhibits substance travel of molten sulfur and sodium polysulfide and that therefore, a large pore diameter is preferable. Moreover, since JP '431

relates to an electrode using molten sulfur, there is no teaching or suggestion of the unexpected advantages of a material having an average pore size of greater than or equal to substantially 5  $\mu\text{m}$  and less than and including 15  $\mu\text{m}$  of preventing an active material in the form of solid phase elemental sulfur (S8) and/or a polysulfide solution from diffusing from active sites of the positive electrode. Even more so, there is no teaching or suggestion of an average pore size of [greater than or equal to substantially 5  $\mu\text{m}$  and] up to 10  $\mu\text{m}$  as required by claim 2 or substantially 5  $\mu\text{m}$  as required by claim 3.

Further, it is respectfully submitted that there is insufficient evidence of record of a motivation to combine Chu and JP '431 in a manner meeting the invention as recited in claims 1 - 4, 8 - 9, 17, 38, and 39. Chu describes its positive electrode as being made from an electrode composition comprising active-sulfur, an electronically conductive material and an ionically conductive material intermixed with the active sulfur (see, for example, Col. 5, lines 1 – 8 of Chu). Chu not only does not mention specific pore sizes of its material, but also does not even mention whether its material has pores at all.

JP '431 describes a battery that comprises an anode comprising melted sulfur and a solid electrolyte. The reference describes that the use of a graphite or felt conductor solves problems of contact resistance that had arisen from using graphite powder with the melted sulfur.

The Examiner alleged that JP '431 discloses that it is essential to use a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000  $\mu\text{m}$  as an electrode member to increase the conductivity of the electrode. The Examiner took the position that it would have been obvious to make Chu's positive active material including sulfur by having the specific pore size of the JP '431 on the alleged grounds that the JP '431 reveals that in a battery system using sulfur it is essential to use a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000  $\mu\text{m}$  as an electrode member to increase the conductivity of the electrode. In other words, the Examiner apparently interprets JP '431 as teaching that a porous conductor consisting of a material having a degree of porosity with pore diameters of 10 – 1000  $\mu\text{m}$  as an electrode member would increase the conductivity of any electrode containing sulfur as an active material, no matter what the structure or composition of the electrode or the nature or phase of the sulfur.

It is respectfully submitted that a person skilled in the art, considering the teachings of Chu as a whole and considering the teachings of JP '431 as a whole would not have found any motivation to incorporate a porous material or a specific pore size described in JP '431 into the

material of Chu. Moreover, in the positive electrode of Chu, conductivity is provided by the fact that the active sulfur is thoroughly mixed with an electronically conductive material and an ionically conductive material (see, for example, col. 5, lines 1 – 8 of Chu.) A person skilled in the art considering the positive electrode of Chu would not have been faced with the same problem described in JP '431 of providing conductivity to a mass of melted sulfur because the active sulfur in Chu is thoroughly mixed with an electronically conductive material and an ionically conductive material. There is nothing in JP '431 that teaches or suggests that the addition of pores to the uniform dispersal of Chu, wherein the active sulfur is thoroughly mixed with an electronically conductive material and an ionically conductive material, would have any beneficial effect on its conductivity. Therefore, the Examiner's alleged motivation to combine Chu and JP '431 in order to achieve an increase in conductivity is without basis.

At page 18 of the Office Action, the Examiner's response to Applicants' previously asserted arguments regarding lack of motivation to combine the teachings of Chu and JP '431 was to state that "the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious." The Examiner cited Ex parte Obiaya, 227 U.S.P.Q. 58, 60, (Bd. Pat. App. & Inter. 1985). The Examiner further repeated the argument that the fact that the applicant has recognized another advantage/disadvantage which would flow naturally from the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. The Examiner further cited In re Keller, 642 F.2d 413, 208 U.S.P.Q. 871 (CCPA 1981) as supporting the statement that "[i]n addition to that, the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the reference would have suggested to those of ordinary skill in the art." These arguments by the Examiner do not address the central issue of motivation. In particular, the fact that Chu presents a different solution to the issue of conductivity, by thoroughly mixing active sulfur with an electronically conductive material and an ionically conductive material, directly relates to the question of whether a person skilled in the art, considering the teachings of Chu as a whole, would have had any motivation whatsoever to consider a reference directed to solving the problem of conductivity and contact resistance in a melted sulfur electrode. Since conductivity is not an unsolved problem in Chu, there would be no such motivation. Therefore, the Examiner has not met the burden of establishing a *prima facie* case of obviousness of claims 1 – 4, 8 – 9, 17, 38, and 39 over Chu and JP '431. Further, contrary to what is alleged by the Examiner, since

the Examiner has not established a *prima facie* case of obviousness, the burden has not shifted to the applicant to prove non-obviousness.

For all of the above reasons, the rejection of claims 1 – 4, 8-9, 17, 38, and 39 over Chu and JP '431 should be withdrawn.

Separate argument for the patentability of claims 4 and 8

As a separate argument for the patentability of claims 4 and 8, these claims relate to a lithium-sulfur battery wherein the positive electrode is prepared by a method comprising mixing an elemental sulfur ( $S_8$ ) powder, a conductive agent, and a binder to provide a positive active material slurry; and coating the positive active material slurry on a current collector. The product that is obtained by these operations is clearly different and distinguishable from any product that would be made according to the disclosures of Chu and JP '431, singly or combined. In particular, claim 4 depends from claim 1 and therefore, the positive electrode is required to include a positive active material including an active sulfur in the form of solid phase elemental sulfur ( $S_8$ ) and/or a polysulfide solution and pores of an average size greater than or equal to substantially 5  $\mu m$  and less than and including 15  $\mu m$ . Chu, while describing the mixture of elemental, active sulfur, electronically conductive material and an ionically conductive material intermixed with the active sulfur does not describe any method of creating an active material having pores or any method that would inherently form a material having pores of the size required by claim 1. JP '431 cannot be combined to supply the missing elements from the disclosure of Chu, since JP '431, as noted above, is non-analogous art relating to a melted sulfur electrode and because there is no motivation for combining Chu and JP '431. Moreover, JP '431 does not describe any method comprising mixing an elemental sulfur ( $S_8$ ) powder, a conductive agent, and a binder to provide a positive active material slurry; and coating the positive active material slurry on a current collector. JP '431 describes forming a porous conductor by combining a graphite felt or cloth with melted sulfur. Clearly, the positive electrode obtained by combining a graphite felt or cloth with melted sulfur, or by incorporating a graphite felt or cloth into an active material would be different, chemically and morphologically, from a positive electrode that is prepared by a method comprising mixing an elemental sulfur ( $S_8$ ) powder, a conductive agent, and a binder to provide a positive active material slurry and coating the positive active material slurry on a current collector. Therefore, the combination of Chu and JP '431 does not teach or suggest a lithium-sulfur battery wherein the positive electrode is prepared by a method comprising the operations described in claim 4. Claim 8 depends from claim 4 and is patentable over Chu and JP '431 for the same reasons given for claim 4.

Therefore, the rejection of claims 4 and 8 should be withdrawn for these additional reasons.

Separate argument for the patentability of claim 9

As a separate argument for the patentability of claim 9, this claim relates to a lithium-sulfur battery wherein the positive electrode is prepared by the method of claim 4 and further by adding a polysulfide solution to the lithium-sulfur battery after preparing the positive electrode. At page 9 of the Office Action, the Examiner noted that Chu at col. 4, lines 30 – 36 and col. 4, lines 60 – 65 mentions the presence of a polysulfide material. However, these passages of Chu clearly refer to polysulfides that form *in situ* upon discharge of the battery. Neither Chu nor JP '431 teach or suggest adding a polysulfide solution to a lithium-sulfur battery after preparing the positive electrode, and clearly, a lithium-sulfur battery having an added polysulfide solution would differ in physical and chemical properties from a lithium-sulfur battery that merely forms polysulfides as a byproduct during discharging. Therefore, Chu and JP '431 do not teach or suggest all the limitations of claim 9, and the rejection of claim 9 should be withdrawn for this additional reason.

Separate argument for patentability of claims 40 - 46

As a separate argument for the patentability of claims 40 – 46, these claims relate to a lithium-sulfur battery wherein the positive electrode is prepared by coating a composition including a conductive agent, a binder, and a plasticizer onto a current collector, removing the plasticizer from the composition coated on the current collector with an organic solvent to generate pores in the composition coated on the current collector; and injecting the polysulfide solution into the generated pores. These claims relate to the same subject matter as canceled claims 10 – 16 and therefore belong to the same elected group as the remaining claims under consideration herein. It is respectfully submitted that nothing in Chu and JP '431, singly or combined, teaches or suggests a lithium-sulfur battery having a positive electrode prepared by a process of coating a conductive agent, binder and plasticizer onto a current collector, removing the plasticizer to generate pores and filling the pores with a polysulfide solution, as required by claim 40. In particular, Chu and JP '431 do not teach or suggest any material having pores with the physical or morphological attributes of pores that are created by removing a plasticizer a composition including a conductive agent, a binder, and a plasticizer. Moreover, Chu and JP '431 do not teach or suggest any material that would be formed by adding a polysulfide solution to the pores of such a positive electrode. Therefore, independent claim 40 defines a lithium-sulfur battery that is clearly distinguishable in physical attributes from anything described in Chu or JP '431.

Moreover, the Examiner is clearly in error in continuing to allege that the porosity of the positive electrode as claimed includes zero porosity or a pore-free material and that no removal of plasticizer is required. Claim 40 depends ultimately from claim 1, which clearly requires a non-zero average pore size. Thus, the allegation made by the Examiner that no removal of plasticizer is required in the claim is clearly without basis. Therefore, claims 40 – 46 are allowable over Chu and JP '431 for this additional reason.

Therefore, in view of the above amendments and arguments, the rejection of claims 1 - 4, 8-17, 38, and 39 over Chu and JP '431 should be withdrawn and new claims 40 – 46 should also be allowed.

**Rejection of claims 5 - 7 in view of Chu, JP '431, and Kovalev et al.**

At pages 9 - 10 of the Office Action, the Examiner rejected claims 5 - 7 under 35 U.S.C. §103 as allegedly obvious in view of Chu, JP '431, and Kovalev et al. (U.S. Patent No. 6,652,440) ("hereinafter referred to as "Kovalev"). The Examiner applied Chu and JP '431 as discussed above. The Examiner acknowledged that Chu and JP '431 do not expressly disclose the specific particle size of the elemental sulfur. The Examiner alleged that Kovalev teaches electroactive cathode materials for electrochemical cells wherein the cathode materials comprise sulfur-sulfur bonds such as elemental sulfur and that the cathode materials are useful in batteries employing alkali-metal anodes, in particular, lithium or lithium alloy anodes and that in one embodiment, the particle size of the elemental sulfur is from 0.01 to 100 microns. The Examiner took the position that it would have been obvious to one skilled in the art at the time the invention was made to use the specific particle size of the elemental sulfur of Kovalev in the lithium-sulfur battery of Chu and JP '431 on the alleged grounds that Kovalev teaches that elemental sulfur having the claimed particle size is useful for making positive electrodes of lithium-sulfur batteries because this particular positive electrode material exhibits satisfactory specific capacity in combination with a lithium anode. For the following reasons, this rejection is respectfully traversed and reconsideration is requested.

As noted above, claim 4, from which claims 5 – 7 depend, would not have been obvious over Chu and JP '431. In particular, JP '431 cannot be combined to supply the missing elements from the disclosure of Chu, since JP '431 is non-analogous art relating to a melted sulfur electrode and because there is no motivation for combining Chu and JP '431. Kovalev does not provide any motivation for combining Chu and JP '431, so independent claim 4 is clearly patentable over these references.

Moreover, in Kovalev, it is described that a dispersion of elemental sulfur having a particle size of 0.01 microns to 100 microns in a liquid medium containing a non-conductive polymer is combined with a precursor of a conductive polymer repeating unit and a polymerization initiator comprising an oxidant and the mixture is reacted to form a grafted organic polymer. See, for example, col. 5, lines 6 – 20 and col. 12, lines 8 – 9 of Kovalev. In other words, the elemental sulfur having the particle size noted by the Examiner is a starting material used in a reaction forming an electroactive, grafted organic polymer. The resulting polymer, as described, for example, at col. 7, lines 19 – 22 of Kovalev is a polymer comprising conductive polymer segments and non-conductive polymer segments, wherein one or more of the conductive and non-conductive polymer segments are bonded to sulfide chains, particularly sulfide chains comprising one or more moieties selected from the group consisting of  $-(S_m)-$ ,  $-(S_m)^-$ , and  $(S_m)^{2-}$  where m is an integer from 3 to 200. It is this electroactive polymer having polysulfide chains that is used in the electrode described in Kovalev. Accordingly, there is no description in Kovalev, singly or combined with Chu and JP '431, of a lithium-sulfur battery wherein the positive electrode is prepared by a method comprising mixing an elemental sulfur ( $S_8$ ) powder having the particle sizes defined in claims 5 - 7, a conductive agent, and a binder to provide a positive active material slurry; and coating the positive active material slurry on a current collector.

Moreover, contrary to what is alleged by the Examiner, there is no motivation to combine the elements described in Kovalev with elements described in Chu and JP '431. Kovalev relates to an electroactive organic polymer that can be used as an electrode material in an electrochemical cell, and the disclosed sulfur particle size is with respect to a method of forming such a graft polymer. There is no disclosure of elemental sulfur of the described particle sizes being used other than in the context of a electroactive organic polymer. There is no disclosure even whether the starting particle sizes are maintained in the graft organic polymer, since the description of the graft organic polymer only states that the electroactive organic polymer has polymer segments bonded to polysulfide chains that comprise  $-(S_m)-$ ,  $-(S_m)^-$ , and  $(S_m)^{2-}$ , where m is an integer from 3 to 200. Moreover, although Kovalev describes that its material has a high energy capacity and other advantages, there is nothing in Kovalev that specifically relates these advantages to the particle size of the elemental sulfur that is used as the starting material in a reaction to form the graft polymer. Kovalev contains no disclosure that would lead a person skilled in the art to directly use elemental sulfur having the described particle sizes in the homogeneous active-sulfur/electronically conductive material/ionically conductive material of Chu.

Therefore, the rejection of claims 5 – 7 over Chu, JP '431, and Kovalev should be withdrawn.

**CONCLUSION:**

There being no further outstanding objections or rejections, it is submitted that the application is in condition for allowance. An early action to that effect is courteously solicited.

Finally, if there are any formal matters remaining after this response, the Examiner is requested to telephone the undersigned to attend to these matters.

If there are any additional fees associated with filing of this Amendment, please charge the same to our Deposit Account No. 503333.

Respectfully submitted,

STEIN, MCEWEN & BUI, LLP

Date: Jan. 16, 2007

By: Ralph T. Webb  
Ralph T. Webb  
Registration No. 33,047

1400 Eye St., NW  
Suite 300  
Washington, D.C. 20005  
Telephone: (202) 216-9505  
Facsimile: (202) 216-9510